

Exercise walk-through

General characteristic chemical properties of the first set of transition ■ 28.2

eXercise

You must be able to

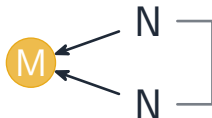
- define a ligand and classify ligands as mono-, bi- or polydentate
- describe complex shapes and deduce coordination number and charge
- describe the ligand-exchange reactions of copper(II) and cobalt(II)

Method — Ligands and complexes

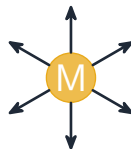
A **ligand** has a lone pair that forms a **dative covalent bond** to the central metal ion.



monodentate: 1 bond
(H_2O , NH_3 , Cl^-)



bidentate: 2 bonds
("en")



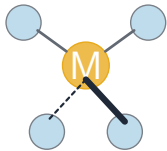
polydentate: many
(EDTA uses 6)

A metal ion with a monodentate, a bidentate and a polydentate ligand

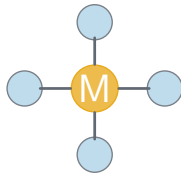
Method — Ligands and complexes



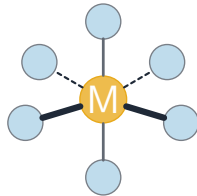
linear
CN 2



tetrahedral
CN 4



square planar
CN 4



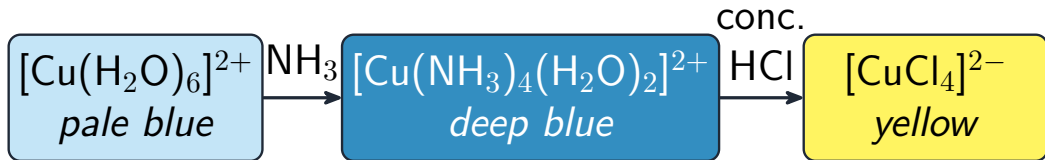
octahedral
CN 6

Complex shapes: linear (2), tetrahedral/square planar (4), octahedral (6)

Method — Ligand exchange

Ligand exchange changes colour: $[Cu(H_2O)_6]^{2+}$ (pale blue) $\rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+}$ (deep blue) $\rightarrow [CuCl_4]^{2-}$ (yellow)

Method — Ligand exchange



Copper(II): pale blue with water, deep blue with ammonia, yellow with concentrated HCl

Practice 2.1 ■ 2 marks

Define a **ligand**.

Solution 2.1

Worked steps

a species with a lone pair of electrons **B1** that forms a dative (coordinate) bond to a central metal ion **B1**.

Practice 2.2 ■ 2 marks

State the coordination number and shape of $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$.

Solution 2.2

Method: Ligands and complexes

Worked steps

coordination number 6 **B1**; octahedral **B1**.

Exam-style 3.1 ■ 1 mark

Which is a **bidentate** ligand?

A H O

B Cl

C 1,2-diaminoethane (en)

D NH

Solution 3.1

Method: Ligands and complexes

A H O

B Cl

C 1,2-diaminoethane (en)



D NH

Worked steps

C. 1,2-diaminoethane (en) forms two dative bonds — bidentate.

Exam-style 3.2 ■ 1 mark

The overall charge on $[\text{CuCl}_4]^{2-}$ shows copper is in oxidation state:

A +1

B +2

C +3

D +4

Solution 3.2

Method: Ligand exchange

A +1

B +2



C +3

D +4

Worked steps

B. $x + 4(-1) = -2 \Rightarrow x = +2.$

Exam-style 3.3 ■ 2 marks

- (a) Write the formula and state the colour of the complex formed when excess ammonia is added to $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$.
- (b) State what is meant by **ligand exchange**.

Solution 3.3

Method: Ligand exchange

Worked steps

(a) $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ **B1**; deep blue **B1**.

(b) one ligand is replaced by another ligand around the central metal ion **M1**, often with a colour change **A1**.

Exam-style 3.4 ■ 2 marks

Deduce the coordination number and shape of $[\text{CuCl}_4]^{2-}$.

Solution 3.4

Method: Ligands and complexes

Worked steps

coordination number 4 (M1); tetrahedral (A1).